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DISCUSSION OF PROCEEDINGS PAPERS

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HIGHWAY DIVISION

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Discussion of
"PERFORMANCE OF SOILS VERSUS CHEMICAL PROPERTIES"

by C. Kinney Hancock
(Proc. Paper 499)

C. KINNEY HANCOCK.[1]—Mr. Huang's concise, general discussion of many of the factors affecting the roadbed performance of soil materials is a helpful supplement to the paper. Also, the writer agrees that the two papers by Professor Winterkorn might well have been included in the references given in the introduction.

As stated in the synopsis and again in the introduction, the soil colloid silica-sesquioxide ratio has been proposed by others and by the writer only as a supplementary index to the raodbed performance of the soil. Certainly, this ratio could not be used as a complete criterion unless all other variables are controlled. However, if the many other factors discussed by Mr. Huang are kept fairly constant, then the soil colloid silica-sesquioxide ratio may serve as a helpful supplementary index to roadbed performance of the soil.

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Discussion of
"THE HIGHWAY SPIRAL FOR COMBINING CURVES OF DIFFERENT RADII"

by Paul Hartman
(Proc. Paper 703)

T. F. HICKERSON,[1] M. ASCE.—This paper is, in effect, a continued Discussion of Separate No. 357—"A Mathematical Examination of Spiraled Compound Curves." Reference is made to Barnett's designations.[2] To set the record straight, this book was preceded by an earlier edition of "Route Location and Surveying,[3] acknowledgment of which appears on page 12 of 2.

So far as is known, Barnett first presented general formulas for the long and short tangent distances to the spiraled compound curve, based on a solution of oblique triangles. These were reproduced in 4 with his permission; but accompanied by an alternate (and preferable) new set of tangent formulas based on the traverse method. Also in 4 is given a formula for β (like the author's Eq. 8 for θ) based on simple calculus, but a new concept nevertheless.

Professor Hartman's paper involves no new procedure except the introduction of the angle β instead of a fixed Δ_2 for the sharper curve. This method is a real contribution to the problem of combining very sharp curves of different radii.

Even with great precision in the deflection angles, slight errors in the curve layout may arise from the usual way of chaining and setting stakes. Actually an error of 100 seconds in angle causes a deviation transversely of not over 0.1 ft at a distance of 200 ft. Frequently pt B (the SC) is set precisely on the forward tangent in advance of the curve layout, by measurements from the P.I., the long and short tangents being known. In cases when the P.I. is inaccessible, pt B would be established by well known procedures. As a rule it would be desirable to hold on to this pt B, although the end of the last chord misses it slightly. The eye could not detect small deviations in sharp curvature, but a displacement of the P.O.T. is significant.

In Professor Hartman's check on the accuracy of his formulas applying to a 200-ft spiral running from a 40° curve to a 20° curve, the theoretical coordinates are: X, 159.398; and Y, 105.088. It is stated that the coordinates by other methods did not differ from these values by more than 0.001. A careful check shows this to be precisely true. Curves of such extreme sharpness, even though not encountered in actual practice, serve as limiting values in the accompanying charts.

Letting $r = \frac{\Delta_2}{\theta_a}$, noting that $K = 1$ when $\ell = L_a$, and converting radians into degrees ($\pi = 3.1415927$), Eqs. 12 and 13, when extended, become:

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$$Y = L_a\Big[\theta_a\left(\frac{\pi}{180}\right)\left[r-\frac{1}{3}\right]-\theta_a^3\left(\frac{\pi}{180}\right)^3\left[\frac{1}{3}r^3-\frac{2}{5}r^2+\frac{1}{6}r-\frac{1}{42}\right]+\theta_a^5\left(\frac{\pi}{180}\right)^5\left[\frac{2}{45}r^5 - \frac{2}{21}r^4+\frac{1}{12}r^3-\frac{1}{27}r^2+\frac{1}{120}r-\frac{1}{1320}\right]\Big]-\ldots. \quad (29)$$

$$X = L_a\Big[1-\theta_a^2\left(\frac{\pi}{180}\right)^2\left[\frac{2}{3}r^2-\frac{1}{2}r+\frac{1}{10}\right]+\theta_a^4\left(\frac{\pi}{180}\right)^4\left[\frac{2}{15}r^4-\frac{2}{9}r^3+\frac{1}{7}r^2-\frac{1}{24}r + \frac{1}{216}\right]-\theta_a^6\left(\frac{\pi}{180}\right)^6\left[\frac{4}{315}r^6-\frac{13}{240}r^5+\frac{1}{27}r^4-\frac{1}{45}r^3+\frac{1}{132}r^2 - \frac{1}{720}r+\frac{1}{9360}\right]\Big]\ldots. \quad (30)$$

The subtractive term involving θ_a^7 is left out of Eq. 29, since it amounts to only 0.009 even when $L_a = 200$, $D_2 = 40^\circ$ and $D_1 = 20^\circ$. For all other cases this item is rarely (if ever) appreciable.

(a) Let $\Delta = \Delta_1 + \Delta_2$, T_1 = long tangent = PB(Fig. 8), T_2 = short tangent = AP(Fig. 8). Then for the 200-ft spiral connecting the 40° and 20° curves:

$$T_1 = \frac{Y}{\sin\Delta} = \frac{105.088}{.8660254} = 121.345; \quad (31)$$

$$T_2 = X - Y\cot\Delta = 98.725; \quad (32)$$

$$\phi_a = 40^\circ - \frac{20^\circ}{3} + C_a = 40^\circ - \frac{20^\circ}{3} + 226'' = 33^\circ 43' 46''.$$

(b) For another method independent of Eqs. 29 and 30,

$$Y = R_2 + (R_1 - R_2 - p_a)\cos\beta - R_1\cos\Delta; \quad (33)$$

$$X = R_1\sin\Delta - (R_1 - R_2 - p_a)\sin\beta; \quad (34)$$

where $R_1 = 286.479$, $R_1 = 143.239$, $\beta = \Delta 2 + C_b = 40^\circ + 9' 54'' = 40^\circ 09' 54''$, and $p_a = p - C_p = 5.792 - 0.071 = 5.721$. Substituting in Eqs. 33 and 34, $Y = 105.091$, $X = 159.399$. Then $T_1 = \dfrac{105.091}{\sin\Delta} = 121.349$ and

$$T_2 = X - Y\cot\Delta = 98.725.$$

(c) Replacing β with Δ_2 and p_a with p, as per the conventional method, and noting also that $\phi_a = D_2 - \frac{1}{3}(20^\circ) + C = 33^\circ 40' 25''$ [where $C = 25''$], we get, by Eqs. 33 and 34; $Y = 105.291$, $X = 159.748$; from which $T_1 = 121.58$, $T_2 = 98.96$.

The error in T_1 and T_2 is about 0.2. An adjustment that might be entirely satisfactory is to establish pt B at the end of the 200-ft spiral as determined by the last deflection angle ϕ_a (slightly erroneous) of $33^\circ 40' 25''$ causing a deviation of not over 0.2 foot. Then with a transit set at this pt B, turn off the angle BAE (Fig. 8) = $\Delta - \phi_a$, thus fixing the corresponding forward tangent.

CORRECTION.—

In the line following Eq. 28, the symbol $p\hat{a}$ should be replaced by the symbol p.

THIS PAPER

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